

Moths of India

– an introduction

Isaac Kehimkar



595.78
KEH
E00259

Edited by Bittu Sahgal
NCSTC-HORNBILL
NATURAL HISTORY SERIES



Moths of India

an introduction

Text and photographs by
Isaac Kehimkar



Series Editor, Bittu Sahgal
**NCSTC-HORNBILL
NATURAL HISTORY SERIES**





Moths of India

– an introduction

Because of their nocturnal habits, moths are among the least known creatures in the insect world. We do, of course, know enough about the Silk moths because these have contributed so much to the well-being of human societies. Nevertheless, the role of moths in enhancing the quality of human life far exceeds this minor benefit. As *Isaac Kehimkar* has so graphically explained, moths are key pollinators of food plants used by humans. What is more, their caterpillars play a vital ecological role in the health of natural ecosystems (often by acting as the food source of other creatures). They do, of course, attack our own food sources, but rather than opt for toxic solutions, he suggests we understand their natural history so that rational, Integrated Pest Management (IPM) solutions emerge.

Jointly published by:

Vigyan Prasara,
C-24, Institutional Area, ASCI Building,
Behind Qutab Hotel, New Delhi-110 016
email: <vigyan@hub.nic.in>

&

Sanctuary Magazine,
602, Maker Chambers V,
Nariman Point, Mumbai-400 021.
email: <bittu@giabm01.vsnl.net.in>

Text © National Council for Science and Technology Communication
and Bombay Natural History Society
Photographs: Sanctuary Photo Library

All rights reserved. Students and researchers may use parts of this manuscript for projects and for other such non-commercial, educational purposes, provided the source and author are acknowledged.

ISBN 81-7480-027-1
NCSTC-HORNBILL Natural History Series
Printed in Mumbai, India by Selprint

The author is contactable at
The Bombay Natural History Society,
Hornbill House, Shahid Bhagat Singh Marg,
Mumbai 400 023

**NCSTC-HORNBILL
NATURAL HISTORY SERIES**

List of plates and illustrations

(not to scale)

(Photographs © Isaac Kehimk)

1. Oleander Hawk moth	cover
2. Sphinx moth	vi
3. Assam Silk moth	3
4. Tussar Silk moth's eggs and caterpillar	4
5. Moth and butterfly antennae	6
6. Atlas moth and Nettle caterpillar	21
7. Monkey moth and Turntail moth	22
8. Goat moth caterpillar and pupation	27
9. Puss moth and Lobster Caterpillar Death's Head Hawk moth,	28
10. Geometrid Caterpillar and Bee Hawkmoth	31
11. Owlet moth	32
12. Wolf spider predating on Ermine moth	34
13. Plume moth and Tiger moth	43
14. Lappet moth and Noctuid moth	44
15. Humming bird Hawk moth	47

Exclusive Distributors:

UBS Publishers' Distributors Ltd.

5 Ansari Road, New Delhi-110 002

Phones: 3273601, 3266646 * Cable: ALLBOOKS * Fax: (91) 11-327 6593

e-mail: ubspd.del@smy.sprintpg.ems.vsnl.net.in

Apeejay Chambers, 5 Wallace Street, Mumbai-400 001

Phones: 2076971, 2077700 * Cable: UBSIPUB * Fax: 2070827

10 First Main Road, Gandhi Nagar, Bangalore-560 009

Phones: 2263901, 2063902, 2253903 * Cable: ALLBOOKS * Fax: 2263904

6, Sivaganga Road, Nungambakkam, Chennai-600 034

Phone: 8276355 * Cable: UBSIPUB * Fax: 8270189

8/1-B, Chowringhee Lane, Calcutta-700 016

Phones: 2441821, 2442910, 2449473 * Cable: UBSIPUBS * Fax: 2450027

5 A, Rajendra Nagar, Patna-800 016

Phones: 652856, 653973, 656170 * Cable: UBSPUB * Fax: 656169

80, Noronha Road, Cantonment, Kanpur-208 004

Phones: 369124, 362665, 357488 * Fax: 315122



Contents

Moths of India

an introduction

Isaac Kehimkar

Editor's note	viii
Publisher's preface	xi
Author's introduction	1
Early history	2
What makes a moth a moth?	5
The life cycle	6
External morphology	13
Rear your own moths	17
A variety of moths	20
Gardening for moths	42
Garden plants for moths	46
Survival – a bag of tricks	48
Of moths and men	52
Glossary	56
Index	60

Editor's Note

The Bombay Natural History Society (BNHS) has been a fount of knowledge for over a century. It has created and nurtured thousands of naturalists from all walks of life. Today the Society continues to add to the body of information gathered by all-time greats such as R.W. Burton, E.P. Gee, J.B. S. Haldane and, of course, Dr. Salim Ali, the 'Grand Old Man of Ornithology.' Long before the subject of environment had become fashionable; before the word biodiversity had even been coined, the study of nature was a mission for hundreds of BNHS members. In time this enduring institution gave birth to an amazing network of amateur naturalists. Their prime joy, apart from tramping India's wilds, has always been to share their experiences, knowledge and information about nature with others.

It is in this context that the production of the National Council for Science and Technology Communication, *NCSTC-HORNBILL Natural History Series* should be viewed. India is losing its natural wealth at a frightening pace and it is vital that decision-makers are exposed to the very real value of the ecological assets being lost to the nation. It is equally important that the rationale for wildlife conservation is understood. Humans, for instance, do not possess the technology to re-create the millions of hectares of natural forests, grasslands and wetlands we lose each year.

To maintain and to enhance the green mantle, which protects our soils and our water sources, we need the elephant to transport mango seeds. We also need chital to carry grasses from one part of the forest to the other as we do the tiny leaf warbler's non-toxic 'pest control' contribution. The cleaning service performed by turtles and crocodiles, frogs and the larvae of dragonflies helps make the water in our lakes and rivers drinkable. Every creature on Planet Earth performs a useful ecological role... save for *Homo sapiens*. We probably started out right, but our capacity for

abstract thought, our intellect and our relatively recent penchant for consumerism, have lulled us into the mistaken belief that we can escape the consequences of the grievous damage we inflict on ecosystems and species. With each forest we lose, each river we degrade, each mangrove and coastline ecosystem we alter, the viability of the Indian subcontinent to sustain future Indians is diminished. Simultaneously the quality of life of perhaps over 100 million earth-people: among them, fisherfolk, forest dwellers, nomads and pastoralists... is lowered and their security compromised.

This latter aspect of the environmental and wildlife movements has only just begun to assert itself in our national psyche. Young people everywhere, social activists and human rights groups are fast recognising that protecting forests for the tiger, rhino and elephant automatically serves to protect both forest cultures and resources for communities which live outside the market system.

In the coming days this new partnership between naturalists and earth-people is destined to play a vital role in defending wild India. In particular, the role of nature in ensuring the food security of millions requires to be understood and highlighted. In this manuscript, *Isaac Kehimkar*, a naturalist and accomplished photographer, shares with us his knowledge of the incredible world of moths. The role these insects play in pollinating plants on the Indian subcontinent is little known. This service makes available, for instance, a vast array of food and flowering plants for human use. If the *NCSTC-Hornbill Natural History Series* manages to enhance the ecological information base of decision makers and to replace pure sentimentalism with pragmatism in the battle to save nature... our purpose will have been admirably served.

*Bittu Sahgal, Editor
NCSTC-Hornbill Natural History Series*

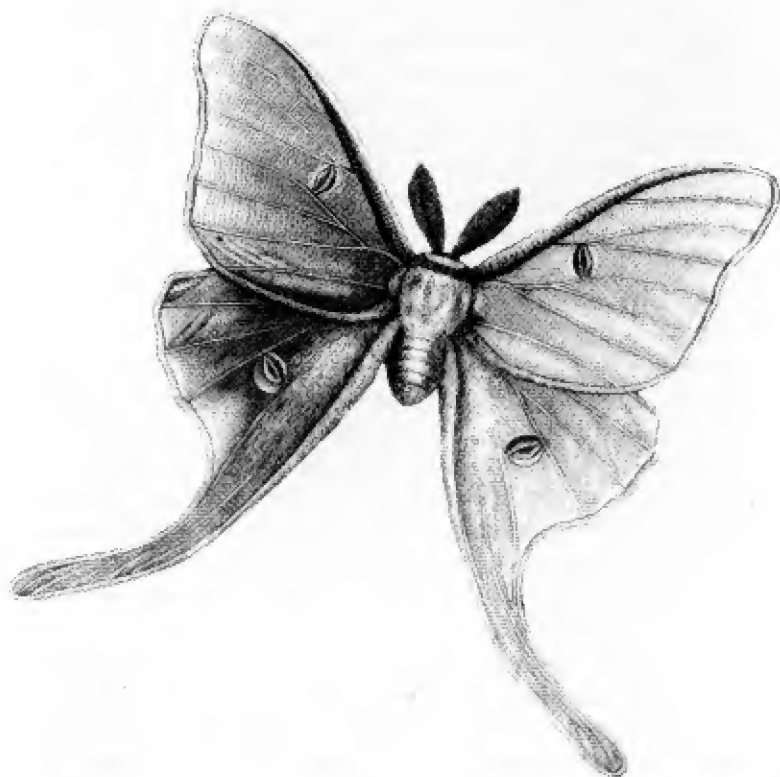
Publisher's Preface

This is one of a series of booklets that have been in the making for years! The wait has been worth it... both in terms of the contents and the fact that we have been able to win the involvement of the most authoritative authors on the various subjects chosen for the titles in the National Council for Science and Technology Communication, *NCSTC-HORNBILL Natural History Series*. NCSTC and the Bombay Natural History Society (BNHS) joined hands to bring the science of natural history to young people though adults too are sure to relate to the style and straightforward presentation. We intend to produce more titles each year to cover as wide a spectrum of nature as possible. We expect the publications to serve the dual purpose of disseminating information and keeping an archival record on the eve of the next millenium.

We wish to demystify the subject of ecology... to make it both understandable and acceptable to India's future decision-makers. The inter-relationships, the complex webs of existence, the contentious and confusing environmental issues... all these will need to be understood and grappled with by tomorrow's citizens. To the extent possible we have stayed away from scientific jargon for obvious reasons. We did not wish this initiative to be reduced to an isolated 'lesson' of the kind one often sees being taught in our schools and colleges.

Isaac Kehimkar has been sharing his love and his knowledge of nature with young people for nearly two decades. Here he informs readers about the wonderful world of moths... dispelling some notions and introducing new ideas. We trust that this (and the other titles in the series) will encourage readers to search for the larger picture, the totality of inter-relationships... and thus aspire towards a better understanding of our own role on this planet.

*Dr. Narender Sehgal, Series Publisher,
Director Vigyan Prasar, June 5, 1997*



Author's Introduction

In spite of the fact that moths out-number butterflies by around 100 times, not much has been written about them. What little information we have is available only on those moths that affect crops or those that produce silk. As a result, there is no concise book on the subject for the lay person. This booklet, therefore, is an attempt to introduce some of the most common and striking species out of the several thousand moths found in India.

India's diverse natural habitats have given rise to an amazing array of moths in different shapes, sizes and colours. From the evergreen rainforests to the potted plants on your windowsill, moths are found everywhere. The moths illustrated and described on the following pages should help you to recognise the different types of moths that commonly occur. The language has been kept simple and as far as possible, technical words have been avoided. However, those technical words that could not be avoided have been explained in the glossary.

The photographs of moths for this book have been taken in keeping with the ethics of wildlife photography. None of these moths were killed, frozen or stuck just for the sake of obtaining a 'perfect picture'. Some moths were, however, reared in captivity, but later they were released into the wild. The moths are shown in their most likely resting positions, but the pictures are not to scale. So far, moths have been studied by collecting them for museum cabinets. That is why, besides their colours and other physical features, very little is known about their ecology. It is time we recognised and studied them as living components of the ecological web of which we too, are merely one link.

*Isaac Kehimkar, Public Relations Officer,
Bombay Natural History Society*

Early History

Arthropoda is a group comprising animals without backbones: invertebrates that have jointed limbs. The group has five major classes: 1. Crustacea (crabs, lobsters, shrimps, etc.) 2. Myriapoda (centipedes and millipedes) 3. Insecta (silverfish, grasshoppers, butterflies, moths etc.) 4. Arachnida (spiders, scorpions, ticks, etc.) 5. Onychophora (*Peripatus*, considered a connecting link between Annelids (earthworms and leeches) and Arthropods).

Insects form the largest group, not only among the arthropods, but also in the entire animal kingdom. They are divided into 29 orders that are in turn broadly grouped into wingless (silverfish) and winged (bugs, butterflies, moths, beetles, flies, etc.) insects. Insects, incidentally, are the only invertebrates that can fly! Insects seem to have made their appearance around 360 million years ago during a great insect 'boom' in the lush, gloomy fern forests of the world.

They are one of the most successful groups of animals, as they have been around much before the dinosaurs roamed the earth. Significantly, they have even managed to survive the onslaught of *Homo sapiens*. Moths and butterflies (*Lepidoptera* group) were among the last to arrive on the evolutionary scene around 160 million years ago, following the evolution of flowering plants. Today, there are about 25,000 known species of butterflies and over 1,20,000 moths. Together, they are second only to beetles (*Coleoptera* group) when it comes to the number of species. Though much of the evolutionary history of these insects is left to guess-work, the very few fossil records that have been found show that the structure and pattern of the wing veins of the moths that existed around 30 million years ago, appear very similar to

"Moths were among the last to arrive on the evolutionary scene, after the flowers."



The Assam or Eri Silk moth is seen here laying its eggs on a castor plant. The eggs come pre-coated with a special adhesive which hardens on exposure to air. The female moth locates a suitable host plant by 'tasting' its surface using special 'taste buds' located on its feet. Each species has a specific food plant which the caterpillars will eat after they hatch from the eggs. Some moths are able to ingest plant poisons so as to make themselves unpalatable to predators. Their inedibility is often 'advertised' by brightly coloured wings and body.



Tussar Silk moth eggs (top) are laid in clusters. When the caterpillars emerge (above) they will feed on the egg shells before moving on to food plants such as ber (Zizyphus) or Arjun (Terminalia).

those found today. Some primitive moths exist even today and are believed to share a common ancestry with caddisflies. These little moths have no proboscis for sucking liquid food, but instead have biting jaws to feed on pollen. This indicates that the early moths had biting mouth parts. Strangely, some moths like the Atlas and Tussar moths have no mouths at all as they do not feed in their very short life span of two weeks as adults.

Moths and butterflies belong to the *Lepidoptera* group (*Lepis* – scale, *Pteron* – wings.) which gets its Latin name on account of its wings that are covered with scales arranged like roof tiles. You

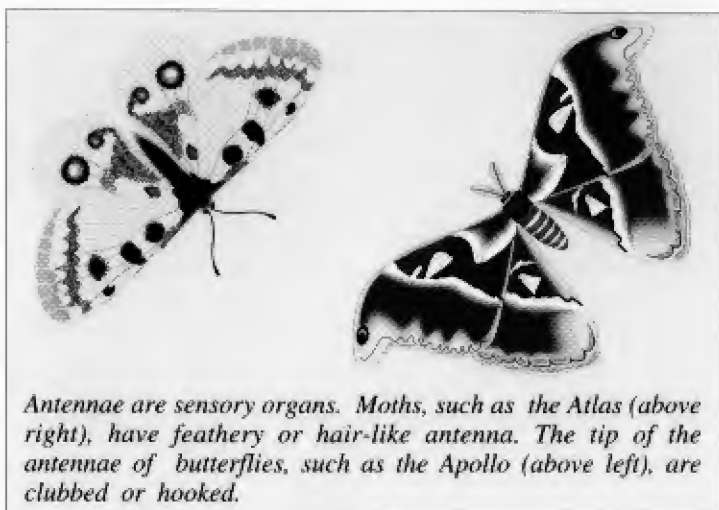
“Early moths had biting mouth parts and were related to caddisflies.”

must have noticed that when you hold a moth or butterfly between your finger, a coloured ‘powder’ comes off onto your fingers. This powder is, in fact, nothing other than the tiny scales with which the moth’s wings are covered.

What makes a moth a moth?

Moths and butterflies have been divided more for convenience, as the division is artificial, based on superficial differences. In the *Lepidoptera* group there are several smaller groups that differ from each other due to certain characteristics. Groups like skippers, swallowtails, whites, yellows, blues and nymphalids have clubbed antennae and are called butterflies, while groups which do not have clubbed antennae are called moths. Though this division is not strictly scientific, it is not likely to be abandoned as it helps people tell moths from butterflies.

Like other insects, moths do not have a skeleton inside their bodies. Instead they have a hard outer covering called an exoskeleton which is composed of a substance called chitin. The exoskeleton protects the soft internal organs and acts as an anchor



for the insect's muscles. This outer covering does not grow during the adult life of the moth. Instead, growth takes place during the larval stage, when the skin is shed several times. The mouth parts of the adult moth are modified into a long, coiled tongue called a proboscis. A moth, of course, goes through several distinct stages in its life cycle: egg to larva... to pupa... to adult. This process is called complete metamorphosis.

The life cycle

The eggs of moths vary greatly in shape, size and colour. A close-up of a moth's egg through a magnifying glass or microscope will reveal a myriad colours and shapes. The eggs may be spherical, elongated or flat with a smooth, irregular or sculptured surface. They may be laid singly, in strings, in bands or in clusters. Hawk moths, for instance, lay eggs singly while Tussar and Moon moths lay them in small clusters on the leaves of favourite food-plants. Tiger and Ermine moths have been recorded laying eggs in large

clusters, all at once, on or near their food-plants. The amazing female Swift moth may lay as many as 50,000 eggs at random while she flies over suitable habitats, which harbour the right food-plants. A large number of eggs or offspring usually ensure against natural wastage. The Lappet and Tussock female moths further protect their newly laid eggs by covering them with abdominal hairs that come off when the abdomen is pressed against the eggs. This is probably the only maternal care noticed among these insects. Almost all eggs are coated with a quick-drying sticky secretion, which helps them to stick to the surface on which they are laid.

"Moth females are born loaded with eggs, but these are infertile till they mate."

Moth females are born loaded with eggs, but the eggs are infertile until the male locates the female. The eggs are laid soon after mating is completed. However, parthenogenesis (virgin birth) or the production of unfertilized eggs without mating has also been recorded in some species of wild silk moths. On hatching these eggs have sometimes been known to produce only females for several generations!

Every egg has one or more tiny openings at the top known as micropyle (which means 'little door'). It is through these openings that the male sperm enters to fertilize the egg. Air and moisture also enter through the same opening, thus helping the caterpillar to develop. Interestingly, eggs change colour as the hatching time nears.

The caterpillar stage is reached when the future flying insect is ready to face the 'outside' world and it bites its way out of the egg in which it was born. The caterpillar now proceeds to make the empty shell its very first meal. It has, in fact, been observed that the caterpillar often cannot survive if it does not eat the shell,

which provides crucial nutrients for the newborn caterpillar in much the same way as the yolk does for a bird hatchling. Now begins the most precarious journey of its life – when the tiny creature must play a deadly game of hide-and-seek to survive. The caterpillar grows rapidly as it must race against time so as to pupate and fly away before a predator eats it. Danger lurks on every leaf and branch in the form of a bird or wasp. But the caterpillar is not quite as defenceless as one might imagine. On being picked up a veritable bag of tricks come to the fore to counter enemies (see page 48).

The caterpillar is virtually an eating machine. It will gobble up virtually every palatable leaf, bud, flower or shoot that comes its way. It must eat thus not only for its own growth and metamorphosis, but also to produce the several meters of silk it requires in crafting a supporting platform while moulting. Its silk also serves as an escape device to drop down and away from attack. Most important of all, silk is used to weave the cocoon. Also, if it is one of those moths that do not eat when it is an adult, the caterpillar must build an adequate fat reserve. Besides this, a female requires additional food reserves for the development of eggs.

Though caterpillars are masters of camouflage, for the observant the presence of half-eaten leaves and small dark-green droppings on the ground below easily point the way to caterpillars in the wild. As a rule, caterpillars eat only plants, but those of the Ermine moths feed on scale insects. Some loopers are known to feed on small flies. And, in overcrowded conditions, or when there is an acute shortage of food, caterpillars may turn into cannibals, devouring the weak and small of their own kind.

“The caterpillar is an eating machine which consumes leaves, buds and flowers.”

During the caterpillar stage, the skin does not keep pace with the growth of the caterpillar's body. But it does stretch to accommodate growth up to a point. When a new layer of skin is formed beneath the old skin, the caterpillar stops eating and comes to rest. Soon the old skin splits behind the head and the caterpillar slowly wriggles free out of its useless vestments. The caterpillar's simple cigar-shaped structure makes this process of skin-shedding or moulting all the more simple. It takes awhile for the new skin to harden and only after this will the caterpillar resume eating, often by consuming its recently moulted skin.

“When there is a shortage of food, caterpillars may well become cannibalistic.”

The shedding of skin takes place three to seven times and the number of sheddings is by no means constant, even within the same species. Interestingly, it has been observed that caterpillars that shed their skin more often than the rest turn out to be females. The stage between two sheddings is known as an instar, and the newborn caterpillar is the first instar.

The caterpillar's cylindrical body is made up of thirteen segments, plus the head. The first three segments behind the head make up the thorax. Each of these has a pair of jointed legs, used mainly for holding food while feeding. These are called true or thoracic legs and each sports a curved claw. The remaining ten segments form the abdomen which usually has five pairs of fleshy, unjointed, sucker-like legs called false, or prolegs. The last pair are called anal prolegs. These are mainly for gripping and for movement. The prolegs are armed with a number of very small hooks, which enable the caterpillar to hold firmly on to its perch. In the case of loopers the number of prolegs may be as low as just two pairs. Which is why they 'loop' rather than crawl for mobility.

Caterpillars of the tiny pollen-eating moths have eight prolegs, while caterpillars which are known as leaf miners are actually legless.

The mouthparts of the caterpillar comprise a pair of very strong biting jaws surrounded by lower lip and upper lip. The upper lip sports sensitive hairs while the lower lip sports the palps and spinnerets. Palps are sensory organs and the spinneret is a pointed outlet from which the silk glands release silk in the form of a liquid that hardens quickly on exposure to air. This is how the caterpillar spins the finest of threads. A caterpillar can sense light and darkness through 12 simple eyes (ocelli): six on either side of the head. It cannot hear as we hear sound, but can feel vibrations through the substrate. There is a tiny pair of antennae, which also serve the purpose of sensory organs.

A caterpillar breathes through the breathing holes or spiracles it has on either side of the segments (except the second and third thoracic and the last abdominal segment). These vents are the outward openings of a network of tubes called trachea. Air sucked in through the spiracle is diffused through a fine network to all parts of the caterpillar's body. The heart and nervous system are spread throughout the body. If you take a close look at the back of a hairless caterpillar just behind the head, an elongated heart will reveal itself, contracting at regular intervals to pump the pale greenish-yellow insect blood called hemolymph.

The pupal stage is reached at a point when internal signals cause the caterpillar to stop eating altogether. It now turns pale and begins to wander restlessly in search of a safe place to pupate. This is when you may come across caterpillars crossing your path or

“A caterpillar's heart and nervous system is spread throughout its body.”

see them entering your house to find a sheltered corner to weave their cocoons. The process of weaving a cocoon is nothing less than an architectural feat. It could take as long as two full days, during which the caterpillar may exude 1.8 km of silk. Each species of moth caterpillar will weave its own unique structure. But not all caterpillars choose to weave a cocoon; some prefer to hide beneath or wrap fallen leaves around them to pupate. Others spin silk among the leaves of food-plants while still others, such as the stem-borers, pupate in the stem itself. The Death's Head Hawk moth is particularly unique. It pushes head-on to burrow

“A cocoon may take as long as two days to be woven, using as much as 1.8 kms. of silk”

into the soil, and when it reaches a depth of 150-160 cm, it pats the soil firmly down with sideways movement, to construct an oval earthen cell in which the metamorphosis will take place.

Cocoons must be strongly constructed, as they must effectively protect the pupa against predators, damp and fungus. Once the caterpillar is well sheltered inside a cocoon or beneath fallen leaves, it sheds the skin for the last time. With the old skin, it also does away with its legs and mouthparts, which it no longer needs. From the outside, the pupa appears quite lifeless, but within, dramatic activity and change are taking place.

The organs and structure of a previously crawling, leaf-eating caterpillar are drastically modified to help make the transition from a pseudo-worm to a flying insect. Organs that are no longer required will now dissolve, providing material and energy for the creation of new organs. A day or two before the moth emerges, its form, pattern and wing colours start showing through the pupal casing. However, in most cases as the pupa is enclosed in the cocoon, this change is missed.

During a favourable season, when there is an abundant growth of food-plants, the time required for the moth to emerge from the pupa is shortest, ranging from 7 to 15 days. However, those caterpillars which pupate at the end of the season will emerge when the next season starts. The Atlas moth caterpillar, which pupates around October, emerges as a moth around July when the monsoon is at its peak.

The adult stage is reached when the caterpillar emerges from the pupa around late evening and dawn. It thus has the advantage of low light or darkness during the most vulnerable stage of its life. The newly emerged moth's wings are crumpled, shrunken and limp. Instinctively, it climbs on to the nearest bush to hang on the underside of a branch, while its wings slowly expand due to the greenish-yellow blood being pumped into the hollow wing veins. At this point it is vital that the limp wings hang freely downward while they harden. If they are obstructed the wings will be deformed and the moth will die because it will be unable to fly. Once fully expanded, soft wings gradually become stronger. If by now it is already day, the moth will stay hidden. By evening the moth is ready to take off on exciting journeys. If it is a male, the moth will set out in search of a newly emerged female whose presence will be picked up by the male's super-sensitive antennae. This receptor can detect specific chemical attractants (pheromones) emitted by the female at amazing distances. Female moths, when they emerge from their cocoons, are already loaded with eggs and they often remain perched while discharging the chemical attractant to help males locate them to mate.

Females of some moth species barely use their wings at all.

“Organs which are no longer required will dissolve and thus provide energy.”

Instead they spend much of their brief life-span laying eggs on precisely the same food-plants on which they themselves grew up as caterpillars. This may be the reason why some female moths are wingless. Female bagworm moths never emerge out of their bags, but lay eggs inside the bag just before dying in the bag itself. In such cases, only males have wings to locate and fly towards the wingless females.

The adult moth can consume only liquid foods, which it sucks through its straw-like proboscis that consists of two highly modified mouth parts held together by a series of hooks and

“Not all moths feed on nectar, some prefer mud, animal dung and even urine.”

spikes, rather like a zip-lock chain, to form a tube. It is coiled like a watch-spring, located beneath the head. The length of a moth's proboscis tells a lot about its feeding habits.

It is strange but true, that some moths like the Atlas, Moon, Tussar and several others have no proboscis – for these do not feed at all during their short adult life span. All the energy needs are met from their fat reserves, stored during the caterpillar stage. On the other hand, Hawk moths have a proboscis longer than the body. This is tailor-made for probing for nectar at the base of long tubular flowers. Not all moths are nectar feeders, as some prefer juices from over-ripe fruits, oozing plant sap, liquid mud, animal dung, urine, human sweat and body fluids of dead animals. A few even visit the eyes of mammals for the saline secretions found there.

External morphology

The body of the adult moth is composed of the head, thorax and abdomen. The head carries a pair of antennae, which may be simple, hair-like or feathery. The antennae are usually better

developed in males as they help to detect the presence of females. The dark, compound eyes are quite prominent on the head. Eyes may have hairs on them, or there may be hair lashes on the sides. The proboscis in some moths is absent or too short to be useful. A pair of sensory pads or palps, is situated one on either side of the antennae. These are organs of touch, but their full and precise function remains a mystery.

Though the thorax is made up of three parts, these are so closely fused as to be difficult to discern separately. The smaller portion that joins the head is the prothorax, the larger middle portion, which carries the forewings, is the mesothorax and the smaller rear portion, connected with the abdomen and sporting the hindwings, is called the metathorax. Each part bears a pair of legs. Besides the digestive tract, the thorax is packed with muscles that enable the moth to fly. The nerves and the dorsal vessel (the heart) keep the blood circulating. But one of the most interesting life-saving organs that moths such as Noctuids, Pyralids and Geometrids possess on either sides of the metathorax are 'ears' (tympanal organs). These 'ears' enable them to detect the ultrasonic sounds emitted by insect-eating bats that hunt moths.

Each wing of the moth is made up of two closely attached thin membranes that are covered with scales on both the upper and undersides. The Bee Hawk moth, however, sheds its scales during its first flight and thus assumes the transparent wings that make it look like a dangerous wasp. The arrangement of scales forms the characteristic pattern and colour of the wings. The colour is either due to the pigment present in the scale or because of the presence of ridges and streaks on the scale, which scatter

“Some moths have special ‘ears’ to help them detect signals from bats.”

light when it falls on the wings. Usually this ridged and streaked structure, rather than pigment, produces blues and greens. Beside these scales, there are specialized scales (androconia) that are found only on male moths. These differ in shape and structure from normal scales and are attached to a scent gland in the wing membrane. Such scales are associated with pouches on the wings containing hair-tufts, which produce attractant scents pheromones, which are necessary for courtship and mating.

The position of veins on the wings is important in classifying moths. In some primitive moths forewings and hindwings have

“Bee Hawk moths shed their scales and begin to look like wasps.”

a similar pattern of veins, whereas in the majority of moths, the patterns are different. The main function of the veins is to strengthen wings for flight and, of course, to help blood circulation.

In most moths, the hindwings link with the forewings during flight, due to a spine-like apparatus on either on the margin of the forewing or the hindwing, depending on the species. Male moths have a single stiff spine or a curved hook, while females sport a group of stout hairs. Emperor and Lappet moths have no such arrangement. Instead, the wings merely overlap, as in the case of butterflies.

Dual purpose legs besides serving the predictable purpose of perching, most moths have highly specialised taste organs located on the base of their feet. In the males of some moth species, the midlegs or the hindlegs have tufts of hair that produce scents (pheromones). Each leg has five segments, with a hip joint (coxa) at the base, a main mobile joint (trochanter), a thigh (femur), a shank (tibia), and a foot (tarsus) which has five joints. Additionally, the foot has a pair of claws.

The abdomen holds and protects the organs of digestion, respiration, excretion and reproduction. Some Geometrid moths have their ears (tympanum), which perform the life-saving function of detecting the presence of insect-eating bats, located in the abdomen. Breathing holes (spiracles) are situated on either side of the abdominal segments. As in the caterpillar stage, these breathing holes are connected to a network of tubes (trachea) through which air is diffused to all the parts of the moth's body.

Scent-producing tufts of hairs that open and close are found on various parts of the abdomen of the males. Though their precise function is not known, it is believed that in some cases the pungent or disagreeable scent keeps predators away, while at other times it serves to attract the female during courtship. Normally, the tufts are located around the tip of the abdomen, but some are located in folds on the sides of the abdomen where they are not easily visible. Some female moths like the *Trabala* have thicker hair-tufts than males. They shed these hairs to cover and thus protect their newly laid eggs. The reproductive organs of the male consist of a pair of claspers with an ejaculatory organ. Enclosed in a sheath between the bases of the claspers, this organ helps to pass sperm to the female. The sperm is stored in a packet (spermatheca) inside the female's body and is released while the eggs are being laid, thus fertilising them. The male reproductive organs help us differentiate between similar species. The female moth has an egg-laying tube (ovipositor) just below the anus. A pair of ovaries located in the abdomen produces eggs that are transferred to the ovipositor, where the eggs are fertilized by the stored sperm before being laid.

Nature is functional to the extreme. Propagation being the main

"Scent producing tufts of hairs are found on parts of the abdomen of males."

aim of these insects, they die soon after the male has mated or the female has laid her eggs. Usually a moth's life span can vary from a week to some months. However, some like the pupa of the Atlas moth are known to survive as long as two years. Such longevity seems to serve as insurance against unpredictable natural factors such as weather that can directly affect the availability of food-plants.

Rear your own moths

Watching a caterpillar perform the architectural feat of weaving

"You can rear moths, provided you take the trouble to learn about their ways."

a cocoon and then witnessing the miracle of emergence is an unforgettable and moving experience. You could watch this all if you rear caterpillars yourself. You should, of course, know how to look after them. Here is how.

First things first. How can you obtain caterpillars? The best time to look out for caterpillars is during the rains. Some caterpillars are seen between March and April, when the trees and shrubs get new leaves. Pea pods (*mutter*) brought from the market may also have caterpillars. Alternatively, a careful search in a bouquet of gladioli or tuberose *rajnigandha* may reveal hidden caterpillars amongst the buds. The rose bush in your balcony may have a hairy tussocked caterpillar or gardenias *anant* may support tailed caterpillars of the Bee Hawk moth. Most of these are easy to look after, but each one has different pupation habits. Incidentally, it is always best for beginners to begin during the rains when there is plenty of fresh food available. A word of caution at this point; be wary of hairy caterpillars as they can give you a bad case of hives if mishandled. Of course, it is possible to procure eggs of the Mulberry Silk moths

from a sericulture centre where mulberry leaves too will be available. These are the easiest moths to raise, especially for beginners. Another viable option is to procure eggs of Eri moths from a sericulture centre. But these will need to be raised on castor.

Caterpillars can be reared in a variety of containers: from jam jars to plastic breadboxes. Airtight containers will cause too much condensation and this dampness encourages fungus and viral infections. All containers should have enough room to avoid overcrowding. Caterpillars need very little air and can survive in closed bottles for a while. The best way to keep the container well ventilated is to cover it with a cloth and secure it with a rubber band. Provide fresh leaves of the food-plant soon after the earlier lot begins to shrivel. And remember, food-plants should be fresh and clean...never wet or stale. Check for insects and spiders on the food-plant...if a predator sneaks in, your caterpillars have little future!

“Avoid handling caterpillars as you could hurt their soft bodies.”

When fresh food-plants are placed, persuade the caterpillars to move on the food-plant, perhaps with a brush. Avoid lifting them with your fingers as even the most delicate handling may injure them. A caterpillar that is reluctant to move may be in the middle of the skin-shedding process, so be patient and leave it undisturbed for some time.

Caterpillars grow rapidly and when fully grown, they stop eating and begin to wander restlessly in search of a suitable place to pupate. You must have prior knowledge of their pupation needs so that you provide the correct medium in which they can pupate successfully. Caterpillars of the Bee Hawk moth and Death's Head Hawk moth, Spotted Lily caterpillar and some loopers

prefer to go under soil, so you must provide garden soil, about 8-10 cm-deep. The caterpillar of the Oleander Hawk moth prefers to bind dried leaves around it to pupate. Paper strips should be acceptable in case dry leaves cannot be obtained.

Most hairy caterpillars weave cocoons and they may choose to pupate on the wall of the jar. This will give you a unique opportunity to watch the caterpillar weaving its own cocoon. Some caterpillars like the Tussar or Trabala can be released on potted plants once they show signs of pupation. But they should be watched till they settle to weave or else they may walk away from the plant to pupate elsewhere.

“Mulberry Silk moths are among the easiest for beginners to breed.”

If you are not sure about the pupation habits of a caterpillar, then provide two to three inches of garden soil, cover it with strips of paper or dried leaves and keep some twigs inside the jar in a slanting position. Now wait and watch while the caterpillars make their own decision! You must ensure that the container has enough room for the moth to dry its wings after emerging, for if the wet wings get obstructed due to lack of space, the moth will be crippled permanently. Once the caterpillar settles to pupate, it should not be disturbed or pulled off under any circumstances. This is very traumatic for them and could result in deformed adults.

Often, instead of the moth emerging from the pupa, you may find to your dismay a parasitic fly or wasp. Do not let it go. Instead, it should be taken to a nearby college or agriculture research centre along with your recorded observations. Today such parasites play a very crucial role in the evolving science of Integrated Pest Management (IPM) which India is opting for to reduce the

amount of pesticide applied to our soils. While the task of rearing these creatures is not difficult, it is crucial that you follow the instructions perfectly. If you make mistakes, learn from them and soon you could be an expert. Once your moths have emerged observe them for a day and in the evening you can carry the container out and watch the moths take off to propagate their genetic chain in nature.

A variety of moths

Hawk moths are the fastest flying moths and are known to travel long distances during their migration. Some have even been encountered mid-sea by ships. Their stout, cigar-shape body with long, narrow forewings are distinctive and help in identifying them. Most have an extra long proboscis, as long as 13 cm! This makes them specialised pollinators of tubular flowers, whose nectar cannot be reached by most other insect pollinators. These moths can usually be seen hovering over flowers at dusk. With luck you may well see one laying a single egg 'on the wing'. Hawk moth caterpillars have a typical horn at the end of the tail. Some have dramatic eye-markings hidden in folds of the skin. When alarmed, these skin segments expand to display the 'eyes'. To add to the effect, the caterpillar will sway its head to convince a potential attacker that it is a snake! Many of these caterpillars are large, almost as thick as your finger, and when alarmed they tend to rear their heads in a sphinx-like posture. That is why they are also called Sphinx moths. When alarmed, the caterpillars as well as the adults of the Death's Head Hawk moth actually squeak (like mice) by exhaling air from the spiracles! On nearing pupation caterpillars turn pale and often change colour. The Oleander Hawk moth's

*"Hawk Moths
are the fastest
flying moths
and can travel
fairly long
distances."*



The Atlas moth (top), the largest in the world (wingspan 33 cm) is found throughout forested India. It does not feed at all in its adult stage (two weeks) and depends instead on fat reserves built up when it was a caterpillar. The Limacodid moth caterpillar (above) presents a fearsome look to potential predators. Attackers that do not heed the warning colouration will suffer a sharp sting from the erect spines visible here. Such lessons are quickly learned, to the advantage of both predator and prey. For obvious reasons these are referred to as Nettle caterpillars.



The Monkey moth (top) uses its yellow and brown colours to good effect to camouflage itself when resting during daylight hours. These moths are normally seen on the fringes of forests and are among the first to suffer the ill-effects of degradation and deforestation. The Turntail moth (above) looks for all practical purposes like a dried leaf. Its curled up abdomen, clearly visible here, is longer than the hind wings. Moths have evolved an amazing array of defences to survive the hazards of life on earth. They often stay motionless for hours on end, merging so completely with the bark or leaves on which they sit. This is because the slightest movement can draw the attention of predators.

caterpillar turns from green to brownish-black as it climbs down to pupate among the leaf litter. Caterpillars of the Death's Head Hawk moth and Bee Hawk moth pupate underground in mud cells.

Only the Bee Hawk moth sheds its wing scales during its first flight that gives it a clearwing appearance of a wasp or a bee. Most insect eating predators like birds, frogs and lizards avoid wasps and bees for their nasty reputation. The Bee Hawk moth and the Humming Bird Hawk moths fly during the day.

Emperor moths are among the most spectacular moths and are

***“Emperor
moths are
known for
their size and
spectacular
beauty.”***

known for their size and beauty. The most notable among these is the Atlas moth, the largest in the world with a wingspan of 33 cm. Indians have known Tussar, Muga and Eri moths for their silk much before the advent of the Mulberry silk moth from China. Surprisingly, adult moths in this group have no mouthparts, as they never eat during their brief life span of two to three weeks. Males have well-developed feathery antennae with which they can pick up the chemical attractant (pheromones) of a newly emerged female by following its scent trail from a distance of a couple of kilometres.

The eggs of this species are laid in small clusters on the food-plants. The caterpillars are stout, often with sparse hairs and tubercles. The cocoon is strong, made of silk and an adhesive substance and is covered with leaves. A strong loop of silk is woven around the branch to secure the cocoon. The moth emerges by exuding an alkaline liquid to dissolve the silken wall of the cocoon. This is the reason why the Tussar and Muga cocoons are immersed in boiling water to kill the pupa, so that the silk strands are not dissolved by the emerging moth. Only the Eri

Silk moths are allowed to emerge and the silk is spun like cotton.

Limacodid moths are less likely to be encountered than their slug-like caterpillars that can leave you with a painful brush of their stinging spines. The caterpillars are characterised by a broad adhesive belly (instead of prolegs) and slug-like movement, which is why they are referred to as slug-caterpillars. Their flat, scale-like eggs are laid in overlapping rows and the caterpillars that emerge are gregarious during early instars when they can be seen congregating on the undersurface of leaves in clusters. They have a unique way of attaching themselves to the leaf surface. A caterpillar will press the side of its belly downward, then raise the centre of its belly up to create vacuum!

Most slug caterpillars have sinister looking tufts of spines and gaudy colour patterns to warn birds and other predators to keep away. Those that do not heed the warning will suffer a searing nettle-like sting even with the slightest brush. You can guess why we call them Nettle caterpillars! Tough, oval cocoons made of a cardboard-like substance are seen on bark, leaves and branches and moths emerge by pushing open a circular lid on the narrow side of the cocoon.

In large scale monoculture plantations of oil palm, coconut and mango, these moths assume pest proportions with entire plantations being defoliated. In the wild the caterpillars feed on several wild plants and are never known for huge population build-ups.

Monkey moths are large, but not quite as large as the Tussar. They are generally yellow to dark reddish-brown with thin wavy lines across the wings. Males have feathery antennae. Some may have a proboscis but most do not. These moths are weak fliers and are

***“Tussar and
Muga moth
cocoons are
immersed in
boiling water
to kill them.”***

attracted to lights. They occur mainly in forested regions. The caterpillars are always seen in groups. These are stout with a thick, uniform coat of long hairs that can cause a rash on a sensitive skin. The caterpillars weave cocoons of silk entwined with their own hairs as reinforcement and protection. Some species weave a loose cocoon in the leaf litter.

Burnet moths are brightly coloured and day flying. The colours serve to warn predators, principally birds, to keep away. A bird or lizard, which puts one of these moths in their mouth, will suffer the effects of a distasteful liquid that oozes out from special glands

***“Bright
colours of the
Burnet moths
warn predators
to keep their
distance”***

situated at the thorax and legs of the caterpillar. Some of these moths mimic the distasteful Milkweed butterflies and Arctiid moths. As distasteful encounters increase, predators quickly learn to avoid similar coloured moths. Another imaginative survival ploy involves dropping from their perch and playing dead, with the brightly coloured abdomen exposed. In some species, the female is larger and has a different colouration. These are more common on hill forests, where they can be seen on damp mud, bird droppings and dead animals. Some caterpillars in this group are known to feed on scale insects, others live in ants' nests. An elongated, leathery cocoon is spun among the fallen leaves and the grass blades.

Goat moths are so named because the droppings of their caterpillars smell goat-like. The stout, grub-like caterpillars are stem-borers. Teak, tea, citrus, cocoa and guava are among their favoured food-plants. Eggs are laid in crevices in the barks of trees. On hatching, the caterpillars bore into the tip of the branch and as they grow, they move on to larger branches. When alarmed, the caterpillars squirt an acrid liquid from an opening

Silk moths are allowed to emerge and the silk is spun like cotton.

Limacodid moths are less likely to be encountered than their slug-like caterpillars that can leave you with a painful brush of their stinging spines. The caterpillars are characterised by a broad adhesive belly (instead of prolegs) and slug-like movement, which is why they are referred to as slug-caterpillars. Their flat, scale-like eggs are laid in overlapping rows and the caterpillars that emerge are gregarious during early instars when they can be seen congregating on the undersurface of leaves in clusters. They have a unique way of attaching themselves to the leaf surface. A caterpillar will press the side of its belly downward, then raise the centre of its belly up to create vacuum!

Most slug caterpillars have sinister looking tufts of spines and gaudy colour patterns to warn birds and other predators to keep away. Those that do not heed the warning will suffer a searing nettle-like sting even with the slightest brush. You can guess why we call them Nettle caterpillars! Tough, oval cocoons made of a cardboard-like substance are seen on bark, leaves and branches and moths emerge by pushing open a circular lid on the narrow side of the cocoon.

In large scale monoculture plantations of oil palm, coconut and mango, these moths assume pest proportions with entire plantations being defoliated. In the wild the caterpillars feed on several wild plants and are never known for huge population build-ups.

Monkey moths are large, but not quite as large as the Tussar. They are generally yellow to dark reddish-brown with thin wavy lines across the wings. Males have feathery antennae. Some may have a proboscis but most do not. These moths are weak fliers and are

“Tussar and Muga moth cocoons are immersed in boiling water to kill them.”

attracted to lights. They occur mainly in forested regions. The caterpillars are always seen in groups. These are stout with a thick, uniform coat of long hairs that can cause a rash on a sensitive skin. The caterpillars weave cocoons of silk entwined with their own hairs as reinforcement and protection. Some species weave a loose cocoon in the leaf litter.

Burnet moths are brightly coloured and day flying. The colours serve to warn predators, principally birds, to keep away. A bird or lizard, which puts one of these moths in their mouth, will suffer the effects of a distasteful liquid that oozes out from special glands

“Bright colours of the Burnet moths warn predators to keep their distance”

situated at the thorax and legs of the caterpillar. Some of these moths mimic the distasteful Milkweed butterflies and Arctiid moths. As distasteful encounters increase, predators quickly learn to avoid similar coloured moths. Another imaginative survival ploy involves dropping from their perch and playing dead, with the brightly coloured abdomen exposed. In some species, the female is larger and has a different colouration. These are more common on hill forests, where they can be seen on damp mud, bird droppings and dead animals. Some caterpillars in this group are known to feed on scale insects, others live in ants' nests. An elongated, leathery cocoon is spun among the fallen leaves and the grass blades.

Goat moths are so named because the droppings of their caterpillars smell goat-like. The stout, grub-like caterpillars are stem-borers. Teak, tea, citrus, cocoa and guava are among their favoured food-plants. Eggs are laid in crevices in the barks of trees. On hatching, the caterpillars bore into the tip of the branch and as they grow, they move on to larger branches. When alarmed, the caterpillars squirt an acrid liquid from an opening

below the head. Some caterpillars are known to live within the stem for as long as two years and more, after which they pupate. The pupa has rings of sturdy hooks along the abdomen, which enable it to wriggle towards the opening of the tunnel when it is time to emerge as a moth. Heavy-bodied, the moths have strong legs with large, sharp claws. Males are smaller than females. The wings are mottled or spotted with colours that blend with the colours of the tree-bark and lichens. These are exclusively forest dwellers.

Silk moths such as The Mulberry Silk moth is possibly the best known insect to man after the honey bee. So domesticated are these moths that today no wild population exist at all. One of the nearest wild relatives of this 'silkworm' is Hutton's Silk moth that occurs from the Himalaya all the way through Malaya and Borneo to Sumatra. This moth too, is commercially bred, for the value of its silk, on mulberry leaves.

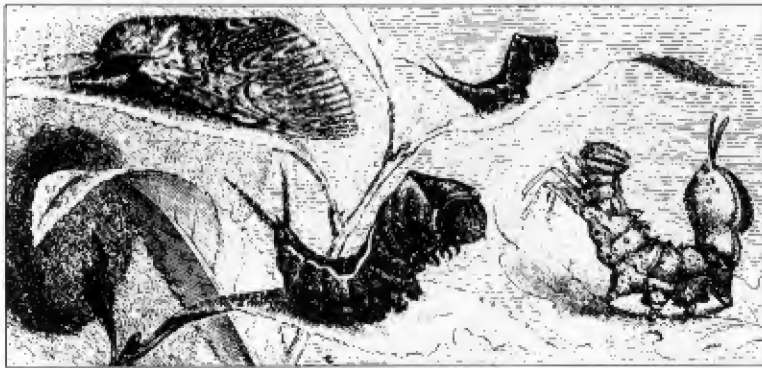
"The droppings of Goat moth caterpillars smell like goats. Thus their name!"

Generally, silk moths are small to medium-sized and do not possess a proboscis. This is because they do not feed during their brief adult life span of one or two weeks. The energy they require is derived from fat reserves accumulated during the caterpillar stage. The males' antennae are prominent and feathery. Females silk moths are larger and more hairy than males.

Silk moths lay eggs in small clusters and some species lay up to 400 eggs. Caterpillars are smooth and elongated with lumps on the back and a small slender horn on the tail end. A majority of them feed on wild figs, peepal and banyan. One species has also been recorded feeding on the sandpaper tree. The caterpillars weave



Goat moth caterpillars, seen at the bottom of the illustration, are known to live within plant stems for up to two years. They will pupate within the stem. Adults, seen at the top of the frame, are heavy-bodied, have strong legs and sharp claws.



The life-cycle of the Puss moth is shown at left. To the right we see the bizarre display of a Lobster caterpillar.



The skull-like marking on its back, earns the the Death's Head Hawk moth its somewhat dramatic name.

a mass of silken cocoons among the leaves of the food-plants. The emerging moths then release an alkaline fluid, which softens the silk and dissolves it, allowing the insect to make good its escape. This, in fact, is why commercial sericulturists must soak cocoons in hot water to kill the pupa. This is the only way to prevent the silken strands from being broken by the emerging moth.

Prominent moth caterpillars occur in strange shapes and forms. Their appearance is often bizarre with some structures abnormally altered as in the case of the Lobster moth caterpillar.

“Generally, Silk moths do not feed at all in their adult phase of one or two weeks.”

However, they are well camouflaged on account of their cryptic forms and colours. Interestingly, caterpillars from the same brood may be turn out to be coloured differently with some resembling leaves and others merging with the bark of trees. This protective adaptation increases the chances of survival within the brood.

Caterpillars of the Lobster and Puss moths spin a tightly woven silken cocoon on the tree trunk, strengthened with fragments of bark, while others go underground, where their silk cocoons are mixed with soil. The moths get their common name from the prominent tuft of hairs on their back that can be seen when the moths are at rest. They have ‘ears’ or tympanum (a sound detecting membrane) on the sides of the thorax, which helps them to detect the soft wing beats of predators such as nightjars and owls. More importantly, they can also make out the ultrasonic signals of insect-eating bats.

Eggar and Lappet moths, at rest, display broad circular hindwings, which may often protrude forward from under the forewings. Most do not have a proboscis, which, as we have seen earlier, implies that they do not feed during their adult stage. Females are

larger and may not fly even when disturbed. Dull, protective colouration with transverse bands makes these moths virtually invisible during the day. Eggs are laid in clusters or bands and during the early instars the caterpillars stay together. Dull coloured and hairy, the caterpillars are difficult to spot on the branches of drumstick, guava and *jamun* trees. The downward-directed hairs on their sides eliminate shadows and render them near-invisible on bark. Alarmed caterpillars display red and black tufts of irritant hairs hidden in the folds of the skin behind the head.

Caterpillars weave their hairs into the cocoon for protection as the hairs retain irritating properties. The cocoons are normally well camouflaged on tree trunks and branches, but those that hang conspicuously have irritant hairs stuck on the twig, on either side of the cocoon to repel predators. During pupation, caterpillars exude a liquid that dries to form a protective powder around the pupa.

“Puss moths can identify the ultrasonic signals of insect-eating bats.”

Tussock moths caterpillars are hairy and often have tussocks of hairs on the back and on either side of the head. Care should be taken in handling these caterpillars as their hairs can cause rashes on sensitive skin. Some of these caterpillars live together in light webs of silk among the leaves. Caterpillars pupate within tough cocoons of silk interwoven with hairs from their body, which retain protective properties to repel predators. Cocoons may be found in crevices of barks, in fences, walls and among leaves and twigs of the food-plants. The pupa too has small short hair tufts that can also cause rash if touched. These are small to medium-sized moths with broad forewings, rounded at the apex. Some may have small a proboscis while others may not have one at all. The male's antennae are more feathery and strikingly larger than



The Geometrid caterpillar (top) mimics a twig even as it anchors itself firmly across the 'V' formed by the branch junction of a gulmohur plant. A typical looper, this caterpillar is also referred to as the inchworm on account of its habit of 'inching forward' as though measuring its path. This form of locomotion has evolved because it does not have as many prolegs as most other caterpillars. The Bee Hawk moth (above) is a day-flying insect which mimics stinging bees and wasps. During its very first flight it sheds the scales on its wings, rendering them transparent and thus perfecting the evolved mimicry.

The false eyemarkings of the Owllet moth will come to its defence when a bird tries to attack it. The 'eye-spots' give the illusion of belonging to a larger creature such as a cat or owl, which most birds will avoid at all costs.





An Ermine moth meets its end thanks to the predatory attentions of a wolf spider. Birds will normally avoid this moth on account of its distastefulness, which obviously does not affect the spider.

that of the female. In some species females are wingless and most have tufts of hairs on their abdomen that they dab on to the clusters of newly laid eggs to protect them. A majority seems to prefer trees as food-plants rather than low-growing shrubs. In mango, tea and citrus plantations, these caterpillars can assume pest proportions.

Forester moths are bright yellow, red and black and are day flying. Such bold colours serve to warn predators to keep their distance. Geometrid moths mimic the warning colours of Forester moths. Fluttering rather than flying, these moths are often encountered

on forest roads and openings. The moths can be seen sipping nectar from favoured flowers, literally trembling with half-open wings.

“Caterpillars exude a liquid which dries to form a protective powder around the pupa.”

Male moths have ‘ears’ on the thorax and some produce a hissing sound while flying. However, the survival value of such adaptations is not known. The caterpillars have bright colour patterns and tufts of hairs on

the sides. Additionally, they have single hairs on small ‘bumps’ (tubercles). These hairs are often split at the tips. Full-grown caterpillars spin strong cocoons of silk either on the ground, in bark or in dead wood.

Bagworm moths are named thus because the caterpillars live within strong portable silken cases covered with twigs, thorns, grasses or bark, arranged longitudinally somewhat like a bag. These bags are a classic example of insect architecture. The unique structure of the bag provides important clues in classifying different Bagworm moths.

The caterpillars never leave their cases fully. Even while feeding, they stay in their packaging, moving about on their forelegs. When

alarmed, they quickly withdraw, turtle-like, into their cases, while still holding on to the perch with their forelegs. Before pupating within the case, they secure the case to a branch or any other support with silk. When males emerge they fly to locate wingless females that never leave their cases. After the female lays her eggs she will die... still inside the case. In some Bagworm moth species, females are little more than egg-laying 'lumps' without wings, legs, eyes or even mouthparts. Without any doubt, these are among nature's most amazing creatures.

Geometer moths get their name from the Latin for earth measurer. Their movement is best described as looping and this is the result of their not having dispensed with the first two or three pairs of prolegs. They move by bringing the rear portion of the body up directly behind the head and forelegs. Hence the name 'inch worm' or 'looper'. In addition to this adaptation, their middle body is unusually elongated to give a longer reach among the leaves of food-plants. Several caterpillars resemble dried twigs or leaf veins. At rest they attach themselves to the perch by the last pair of their strong prolegs, with the body projecting twig-like at an angle. This renders them almost invisible. Most Geometer moths favour trees and shrubs as food-plants. However, there are some which feed on flowers and can change their colour to remain hidden among the petals.

Caterpillars of a Hawaiian species actually catch flies and other insects on which they feed. When attacked, the caterpillars of some species vomit out a green secretion. Fully-grown caterpillars burrow in the soil to pupate in mud cells, while others pupate in light webs which they weave among leaves.

"Some Bagworm moth females have no wings, legs, eyes or even mouth parts."

Geometers are slender-bodied moths with comparatively large wings. All day long they take advantage of their cryptic colouration to stay hidden in the foliage of trees or on tree trunks. Most have a pattern of wavy lines running along forewings and hindwings. Females of some varieties are wingless or have underdeveloped wings. Some bright-coloured Geometers are day flying. Some such as the noctuids are attracted to the saline secretion that flows from the eyes of cattle.

Hook Tip moths get their name from their hooked forewings. Their dull yellow-brown colour and the dark line that extends from

"Caterpillars of a Hawaiian species actually catch and eat flies and other insects."

wing tip to tip, give them the appearance of a fallen leaf. This is why they spend the day hidden in the leaf litter, safe from predators. Additionally, several have silvery markings dusted on their wings. Their slender caterpillars look like the typical looper, but they do not have anal prolegs.

The rear portion is thickened, and raised when at rest and other parts of the body are often humped. When fully grown, the caterpillars pupate among fallen leaves.

Uranid moths sport delicate grey lines on white wings and have toothed hindwings. These unmistakable trademarks suggest their close relationship with Geometer moths. Small to medium-sized creatures, these moths are commonly found in wet, forested regions. During the day they can be seen resting on the leaves of low shrubs with their wings spread close to the surface. In the evening they can be seen on walls particularly around light bulbs. The caterpillars are typical looper-like. However, they differ from the Geometers in the number of legs and prolegs. When fully grown, the caterpillars climb down to pupate in the leaf litter where leaves will be bound together with silk to facilitate safe pupation.

Arctiid moths produce hairy caterpillars that are commonly referred to as 'woolly bears'. These can be encountered in gardens where they feed on a wide range of wild and cultivated plants. Many of their food-plants are poisonous or distasteful and if you accidentally brush against the caterpillars their hairs may give you a nasty rash. As with so many other similar moth species, caterpillars interweave the stinging hairs into cocoons to keep predators at bay. The caterpillars live together during their early instars. This grouping together is a deterrent to predators. Arctiids are small to medium sized moths and are often commonly called Footmen, Tiger, Ermine and Handmaiden moths. The tympanal organs or 'ears' which enable them to hear the high frequency calls of the insectivorous bats, are located on their thorax and abdomen. There are some distasteful moths among them, which, on sensing a bat, start emitting their own ultrasonic clicks by bending and unbending a stiff cuticle on the third pair of legs, in rapid sequence. This way they make themselves visible or rather audible to insectivorous bats. Bats learn to associate these clicks with distasteful encounters and therefore avoid the sound-producing moths!

Footmen moths are narrow-winged and have a thin abdomen around which they fold their wings. When disturbed, instead of flying away, they drop down or jump from their perch and 'play dead' in the leaf litter. Long hind legs enable the jumping. A bird which pecks at them will encounter a distasteful oily secretion from glands around the head. Some of these moths produce a high-frequency sound while flying.

Males of some species are smaller and have a different colouration from the females. This has often misled entomolo-

“Arctiid moths produce hairy caterpillars that are commonly called Woolly Bears.”

gists into believing that the two sexes are actually two different species of moth. Their hairy caterpillars can be seen on tree trunks feeding on mosses and lichens. When alarmed, they too may drop down or perhaps hang suspended in mid-air with the help of silken anchor strands. Caterpillars pupate in tightly woven silken net, in a rolled up leaf or in a crevice in the bark of a tree.

Tiger and Ermine moths are larger than Footmen with more stout and hairy bodies. Their wings are usually white or cream-yellow with darker spots. Most do not have a proboscis. If there is one, it is generally too miniscule to be of any real use. Hairy caterpillars

“Males of some species are smaller and have different colouration from females.”

are seen on low-growing plants and grasses and light silk cocoons are interwoven with hairs among leaves, leaf litter or under any suitable shelter.

Some day-flying moths, *Nyctemeres*, are included in this group, which can be seen fluttering weakly over open patches of low vegetation. Birds soon learn to avoid these slender-bodied moths, because of their acrid taste, the result of secretions from glands in the thorax and abdomen. The caterpillars are gregarious and have black tufts on the back and a pair of forward-pointed tufts on the either side of the head. Strangely, their cocoons are sprinkled with fat globules that look for all the world like droplets of melted butter! The exact purpose of these fat globules has never quite been explained.

Handmaiden moths look like dangerous wasps. These slender-bodied moths fly fearlessly about in broad daylight. The ringed bands on the abdomen, coupled with transparent, spotted wings make for an excellent masquerade. So sure are these moths of the disguise that they are often reluctant to fly away, even when

disturbed. They are fond of flowers and flock around light in the evening. Their round, yellow eggs are laid in large clusters on the food-plants or on the ground. Dull coloured caterpillars are short and have dense hair tufts typical of Arctiid caterpillars. They feed on low-growing plants some of which are distasteful. Caterpillars weave flimsy, dark-coloured cocoons entwined with hairs, amidst favoured food-plants.

Noctuid moths comprise a varied assortment, including the 'pest' moths of the notorious Pod Borers *Helicoverpa*, to the queer Turntails whose curled-up abdomen is longer than their hindwings. Large Owl moths that display owl-eye markings on their wings also belong to this group. Most are heavy-bodied and escape the attention even of keen-eyed birds due to their dull, cryptic forewing markings that merge with tree trunks, boulders or dry leaves where they rest during the day. Some tuck their bright coloured hindwings under the forewings and when disturbed, they take off, flashing their bright colours momentarily to confuse predators. This gives them the opportunity to fly away and disappear in moments, on a tree trunk or among the fallen leaves, even as the would-be predator continues its search for its bright coloured prey. With the 'ears' (tympanal organs) situated on the hind-most part of the thorax, these moths pick up the scanning ultrasonic calls of the insect-eating bats, and thus avoid being eaten.

Fallen, over-ripe fruit with oozing juices are their favourite food. However, some Noctuids do not wait for the fruit to fall, preferring instead to pierce the fruit with their sharp-tipped proboscis which is lined with very small teeth and spines. Some moths even draw sustenance from the saline secretions of the eyes of cattle.

"Birds learn to avoid some day-flying moths because of their acrid taste."

The near-spherical eggs are ridged and are laid in small clusters on favoured food-plants. Most caterpillars are hairless and will stay hidden until nightfall. However, the bright, spotted Lily caterpillars can be seen during the day walking up and down fearlessly among the garden lilies. The warning spots keep hungry birds away quite effectively. Some caterpillars are called semi-loopers because one or two pairs of their prolegs are either absent or too small to help in walking. That forces them to move about in a looping manner akin to caterpillars of the Geometer moths. Though all the caterpillars are vegetarian, the caterpillars of *Eublemma* moths eat mealy bugs and other scale insects, which

"Some moths settle around the eyes of cattle to suck saline secretions."

are considered as plant pests. A majority of these caterpillars pupate in the soil in mud cells bound by silk. Some choose to pupate in cocoons spun in foliage or in the leaf litter.

Plume moths are small, delicate, grey coloured moths with feathery wings, which leads them to be easily mistaken for grass seeds! These thin, long-legged moths are commonly seen in short grass. Their forewings are split and the hindwings have two splits. When disturbed, these weak fliers settle quickly after making a short escape flight. Oval, smooth eggs are laid singly on leaves, flowers or fruits. Some of them, like the Grape Boring Plume moth and *Exelastis* Plume moth, are destructive to orchards as their caterpillars are voracious eaters of buds, flowers and pods. Some are known to consume the flower heads of lantana and can serve a useful purpose in containing this rampant weed. Spiny pupae are attached to the food-plants.

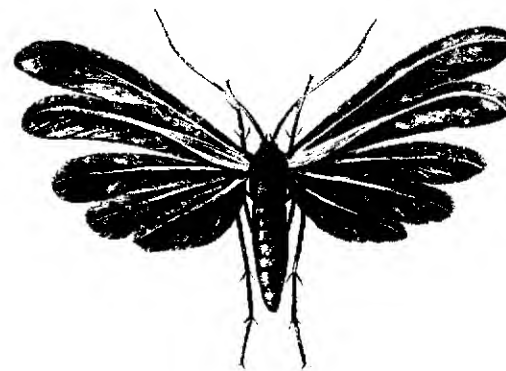
Pyrilid moths constitute a large group of small moths within which are several smaller groups, most well known to man. Many

of them, in fact, are considered to be pests. These moths are usually long-legged with a somewhat translucent appearance. Some rest with their wings spread close to the surface while others opt for the typical tent-like posture and some actually roll their wings round the body. Among the smaller groups is the Grass moth, whose caterpillar lives in silken galleries crafted within the stems, crowns and roots of grasses. Some of the most troublesome of these are the familiar Sugar-cane stem borer, Dark-Headed striped borer and the Asiatic rice borer *Chilo* sp. They sit on grass stems with their wings rolled round the body presenting a wedge-shaped look. The other well-known group is that of the Wax moths whose caterpillars riddle beehives. The Horn moth caterpillar gnaws through the horns of dead cattle and their tough leathery cocoons project out of the horns. Some Pyralids can do serious damage to grain stored in godowns and houses. These fascinating moths occupy a different range of habitats. The rice-case worm, for instance, lives underwater. It has hair-like gills on the sides of its body and obtains oxygen from the water in its leaf case. The Cactus moth was used successfully by entomologists to control the Prickly Pear *Opuntia* that had encroached on thousands of acres of fertile land in India and Australia.

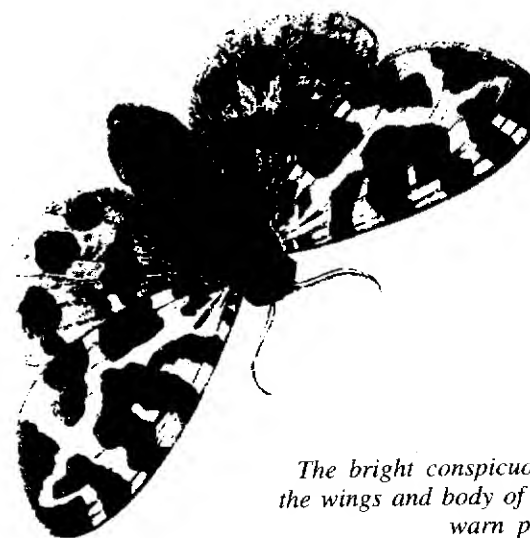
Gardening for moths

Moths are great botanists and can tell one plant from another with consummate ease. Planting the right type of plants in your garden or the window-sill will reveal their uncanny ability to locate favourite food-plants. Moths lay eggs on plants, on which their caterpillars can feed and grow. They will also visit these flowers for their nectar. Choosing plants for moths delivers you a dual

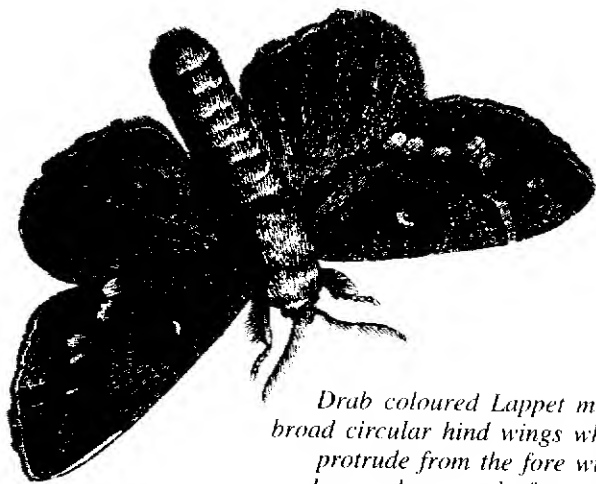
***“Plume moth
caterpillars
harm orchards
... eating buds,
flowers and
pods.”***



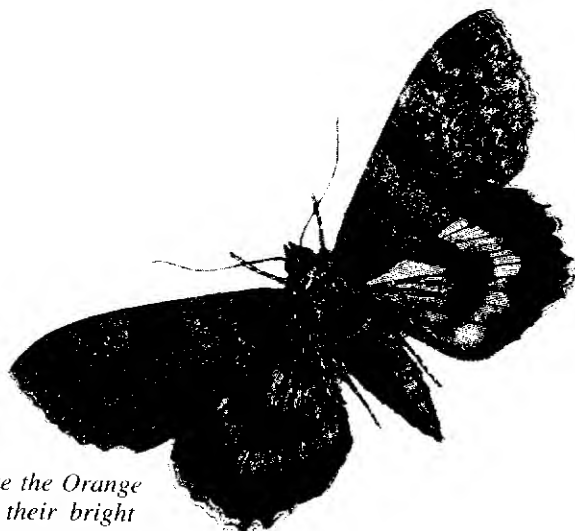
Plume moths are small and delicate, with feathery wings and can be easily mistaken for grass seeds. Camouflage is a survival art.



The bright conspicuous patterns on the wings and body of the Tiger moth warn predators away.



Drab coloured Lappet moths have broad circular hind wings which often protrude from the fore wings. Females are large and often may not fly even when disturbed.



Noctuid moths like the Orange Underwing flash their bright coloured hind wings to confuse the predators.

benefit, your garden will be aesthetic – and alive with flying insects who are normally so secretive that only a select few can enjoy them.

Once you know that the moths have actually found your garden, you can discover much more about insects by hanging a sheet of white cloth outside and affixing a light bulb or tube light over the sheet. Insects will be attracted to your 'light-trap' from far and near. You can be sure that several moths will be among these visitors. Most will settle on the sheet, which provides enough contrast for you to examine them well.

“You can attract moths to your window-sill by planting their favourite species of plants.”

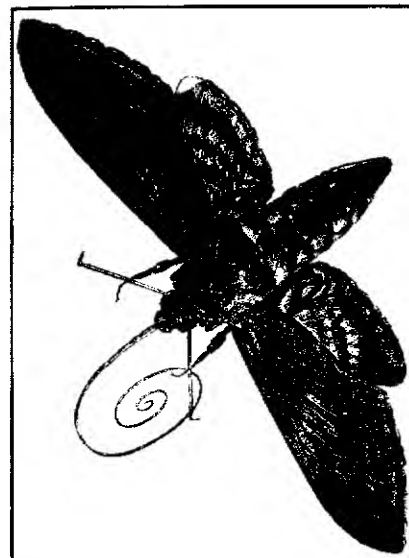
There are some tricks of the trade you might like to know about. Keep a vigil on a new moon night and your results will be better. Put some overripe guava, banana or pineapple (or any aromatic fruit) out in the open and the diversity of moths and other night fliers will astound you. Always make notes on your observations, these will help you compare different events spaced months or years apart. Don't forget to record whether it was a full moon or moonless night. Also, keep track of the date, time and weather conditions. Soon you will have a list of the different moth visitors. Of course, you should keep a note of preferred plants for food and egg-laying. Very soon you will discover much more about the natural history of moths than you had ever thought possible. In the process, you may even stumble upon new information, unknown to science. Remember that you can always compare your observations with those of others by referring to reliable sources such as the BNHS Journal and other references on entomology. Unique observations may even be published by such journals.

Garden plants for moths

Food-Plants	MOTHS
1. Saplings of Mango, Jamun and Coral	– Slug Caterpillar
2. Golden Fig <i>Ficus benjamina</i>	– Wild Silk moth and Tussock moth
3. Ber <i>Zizyphus</i> and Indian Almond <i>Terminalia catappa</i>	– Tussar Silk moth
4. Saplings of Jamun and Guava	– Lappet moth
5. Gardenia or Anant	– Bee Hawk moth
6. Bitter Hedge Plant	– Death's Head Hawk moth
7. Common Jasmine or Chameli	– Death's Head Hawk moth
8. Oleander or Kaner	– Oleander Hawk moth
9. Rangoon Creeper or Madhumalti	– Vishnu Lappeat moth
10. Castor Plant or Erand	– Castor Semi-Looper moths
11. White Spider Lilies	– Lily moth
12. Elephant Foot Yam or Suran	– Silver-striped Hawk moth
13. Indian Rosebay or Tagar	– Rosebay Pyralid moths

Nectar-rich plants visited by moths

1. Lantana (white flowering)
2. Bitter Hedge *Clerodendum inerme*
3. Evening Primrose or Gulbakshi
4. Balsam *Impatiens*
5. Petunia
6. Periwinkle or Sadphuli (white flowering)
7. White Spider Lilies
8. Verbena (white flowering)



Hawk moths and tubular flowers appear to be tailor-made for each other's needs. Hawk moths are equipped with an extra long tongue to reach the nectar glands at the base of the long slender tubular flowers.



While most Hawk moths visit night blooming flowers from dusk onwards, the Humming Bird Hawk moth and the Bee Hawk moth use these resources during the day. This is yet another example of the efficient use of nature's resources. All adaptations are geared to ensure survival in a harsh environment. Those that do not adapt... die.

Survival – a bag of tricks

The very fact that moths exist today, since their first appearance around 160 million years ago, shows that these insects were able to adapt whenever their survival was at risk. Such dangers are not inconsiderable. Moths are under attack at all stages of their lives from a variety of predators with some eating the eggs and others the caterpillars and adults.

Every offence, of course, sooner or later produces a counter-defence. Hawk moths lay their eggs singly, thus ensuring that eggs are distributed over a wide area so that all their “eggs are not in the same basket.” Moths like the Tussar and Atlas lay their eggs in small batches over different food-plants, so that even the competition for food is reduced among their caterpillars. Females of the Tussock and some Lappet moths cover their newly laid eggs by dabbing protective hairs from the tip of their abdomen. Certain moths lay eggs in unusually large numbers, probably to make an allowance for the loss of eggs destroyed by predators. Almost all moths lay eggs where they are not easily seen, such as on the underside of leaves or in bark crevices.

Clearly, the caterpillar stage is the most vulnerable phase in the moth's life. Birds eat caterpillars, as do other small animals including rats, shrews, lizards, frogs, beetles, bugs, ants and even spiders. Then there are the specialised predators such as parasitic wasps and flies. The Ichneumon wasp, for instance, lays its eggs on, or even inside the caterpillar's body using a needle-like egg-laying tube that pierces the caterpillar's skin. The wasp grubs, on hatching, begin to consume the insides of the caterpillar without

harming its vital organs so that the caterpillar lives on and on to ensure a continuous supply of fresh food. When the grubs emerge to pupate their host is left hollowed-out to die. This could well happen to one of the moths you hoped would emerge from a cocoon you were watching. What you might see instead are a few hairy flies or wasps. And then there are bacteria, virus and fungus that result in blackened, liquefied caterpillars.

With so much predation pressure, moth caterpillars have evolved protective colouration and defensive behaviour to avoid being eaten. Little wonder then that these caterpillars come in so many

“The caterpillar stage is the most vulnerable one in the lifecycle of moths.”

shapes, colours and sizes. Every single one of them has a very purposeful survival value.

Several caterpillars feed at night, to remain undetected by day-flying predators. By daybreak they go back into hiding among the fallen leaves or in the food-plants.

They are able to remain ‘invisible’ during the day. Using greens and browns to good effect they are able to merge with their food-plants, sometimes even mimicking the veins of a leaf, or by using lateral lines to optically break up the body outline amidst blades of grass. Loopers attach themselves to twigs in a manner which makes them look like part of the plant. Yet, keen-eyed birds manage to consume large numbers.

Some caterpillars roll leaves around them with silk. Stem-borers conceal themselves within the plant stems or roots and leaf miners within the leaves. The parasitic Ichneumon wasp has cracked most of these defensive strategies. Using extra long egg laying tubes to reach them, they deposit their next generation in just the right place to ensure a plentiful food supply. To keep off parasitic

wasps and flies, caterpillars such as the Woolly Bear, are protected by an armour of irritating hair. But most cuckoos relish hairy caterpillars! To ward off birds, slug caterpillars have formidable spines and gaudy warning colouration. Every spine is equipped with a poison gland at its base, yet Assassin bugs manage to suck slug caterpillars dry! The spotted Lily caterpillar has bright spots to advertise its inedibility thanks to toxins acquired from food plants.

Some Hawk moth caterpillars have a pair of staring false eyes that give them a fearsome look, which is enhanced by a menacing snake-like wriggle. Most potential attackers are scared away, thinking they tried to take on a snake. This ploy does not work with parasitic wasps and flies. So every protective device, it can be seen, appears to fall just short of perfection, yet each is effective in the sense that the attack is limited to specific predators thus preventing wholesale destruction. Camouflage or concealment is essential during pupation too since the pupa cannot move away if danger threatens. The best concealment is to go underground. Some caterpillars pupate in leaves spun together, others in the plant stem or in leaf litter. Of course, it is the silken cocoon that provides the best protection. Hairy caterpillars interweave their hair into the cocoon, which manages to retain the irritating properties. Thus, a predator, which tries to get to the pupa, will get a face full of stinging hair. The cocoon of the Tussar is a virtually impenetrable fortress of silk, which effectively protects the quiescent pupa even against damp, mould... and predation. Tough cocoons are vital for species that aestivate till favourable conditions prevail. Cocoons woven on branches and bark are drab-coloured to merge with the surroundings.

“Every single caterpillar trait has a purposeful survival value.”

Birds love to eat moths, as anyone who has spent time observing birds will confirm. Adapting to a nocturnal life-style has not fully solved the moth's problem of avoiding aerial attacks. Insect-eating bats, owls and other nocturnal birds take a heavy toll of moths. In addition, geckos and hundreds of other small insectivores have chosen a nocturnal existence to avail of the opportunity presented by night-loving insects such as moths.

Over the past 50 million years, moths have quite literally engaged themselves in an evolutionary arms race with their predators. For example, insect-eating bats discovered echolocation to capture insects on the wing. Moths in turn evolved ‘ears’ which are sensitive to high frequencies. A moth can therefore hear an approaching bat at a distance safe enough to make good its escape. Moreover, the moth's furry body muffles the scanning signals of the bat. It is to the moth's advantage to move as silently as possible, as even the wing-beats can be heard. Moths have, therefore, evolved fine hairs bordering their wing edges to make their flight noiseless. By contrast, on detecting the presence of an approaching bat, Arctiid moths start emitting their own ultrasonic clicks by rapidly bending and unbending a stiff cuticle on their third pair of legs in sequence. What seems suicidal is in fact a survival strategy. The moth wants the bat to know it is there because it is extremely unpalatable.

This can be likened to the manner in which day-flying moths display bright colours to visually warn away potential predators. And, just as some edible day-flying moths mimic the colours of poisonous moths, some defenceless night-flying moths have learned to emit the series of clicks to send bogus warning signals

to insectivorous bats! The survival bag of tricks is ever changing.

The day-flying Bee Hawk moth has transparent wings and yellow and red bands much like those which larger bees and wasps have on their backs. In this case, mimicry is perfected to the extent of developing a 'buzz' as well. This trick seems to work well as it has been found that most insect-eating birds, lizards and frogs tend to avoid bees and wasps. While night provides a cloak of anonymity, the advent of day presents moths with problems galore. This is when thousands of insect-eating birds and lizards are active and hungry.

The problem is solved by an astounding ability to conceal themselves by mimicking bark, lichens, leaves, excrement and other objects such as broken twigs or even grass seeds. Towards this end, pigments, patterns and postures are used in combination to near-perfection.

***"The moth
wants the bat
to know it is
there since
it is so
unpalatable."***

Of moths and men

Problems: Ever since man gave up his nomadic lifestyle and settled down to cultivate crops, he has had to face the onslaught of competitors like insects, birds, rats, squirrels and monkeys. Among insects, many moths too have conspired to deplete his food stocks and supplies. Such moths come in all sizes. The tiny, Brown House moth caterpillars feed on a variety of stored foods such as pulses, grain, flour and even hay. Clothes moth caterpillars feed on wool and woolen garments, blankets and carpets. Other notorious species include Cutworms, Pod and Stem Borers and Bollworms.

Today, the need to grow more food is greater than ever before,

as the human population grows by leaps and bounds. Vast stretches of natural vegetation have therefore been brought under cultivation. While several moths suffered due to loss of habitat, others managed to change their lifestyle to encompass cultivated crops under the new man-made conditions. Large scale, intensive cultivation, often of a single type of crop, has favoured certain moths and led them to proliferate to pest proportions. Humans responded by using insecticides.

Initially, after World War II, when several powerful insecticides were developed, it was felt that the war against insects had been

***"We have not
begun to fully
comprehend
the complex
insect-plant
relationships."***

won. However, after a number of years of repeated and often excessive use of insecticides, it was found that insects began to develop resistance to insecticides. This resulted in tremendous harvest failures caused by these super-insects. But the worst fall-out was that these toxic insecticides accumulated in the tissues of every living being including humans, resulting in disease and deformation, particularly of newborn babies.

Fortunately, more and more people have become aware of the dangers of insecticides. To find alternatives, scientists have taken a closer look at the pest species in relation with the environment. The world over, farmers are being encouraged to use a combination of techniques to control pests which also include the use of narrowly targeted insecticides that kill only the chosen pest species after which they break down harmlessly. Called Integrated Pest Management (IPM) this new pest management technique involves the use of natural predators such as parasitic wasps and flies, bacteria, viruses and fungi.

Potential: The Chinese were the first to rear mulberry moths for

silk—a secret they zealously guarded for ages. However, ancient Indians knew the Tussar, Muga and Eri moths as well and harvested their silk. Today, India is the fourth largest producer of raw silk. Besides the Mulberry silk moth, Eri and to some extent Muga in the Northeast have been domesticated fully by man. However, all attempts to domesticate Tussar silk moths have failed. These cocoons are only collected from the wild and this task is performed almost exclusively by *adivasis* (tribals) who know the forest and the habits of the Tussar.

The Eri silk moth, whose caterpillars feed on castor, has been selectively bred to produce a pure white silk, which is normally dark reddish-brown in the wild. Significantly, this silk is not reelable, but is spun instead like cotton, thus there is no need to kill the pupa to obtain silk. The gift of silk to mankind makes these moths among the most beneficial insects in the world. Silk is a multi-billion dollar business the world over.

Moths also play an extremely vital role in pollinating some night-blooming flowers, so that their seeds and fruit can form. More importantly, they are part of nature's web and form a vital link in the food chain as sustenance for spiders, birds and mammals. In parts of Africa, Mopani caterpillars are actually fried and eaten as snacks! We have not even begun to fully comprehend the complex relationship between plants and insects, but we can be sure that this is one of the most vital parts of nature's strategy for maintaining life on earth.

Our indiscriminate use of pesticides, particularly organochlorines, displays a fundamental lack of understanding of the manner in which earth's systems work. Insects, including moths, are

reputed to be the most successful animals to live outside the sea. We cannot win a war waged against them. On the other hand, by understanding their ways and by making minor adjustments in our own way of life, we could learn to avoid their most harsh impacts, even as we take advantage of their tremendous potential to contribute to the quality of our own existence.

***“Insects began
to develop
resistance even
to our most
deadly pesti-
cides.”***